

3. THE ECHINODERMATA

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With Plate 6 and Text-figs. 1-12.

THE collection of Echinoderms taken by the "Rosaura" includes specimens from off Greenland and north-east America, as well as from the West Indies and one station off the north-west coast of Africa.

Some of the Echinoids were identified by the late Dr. Th. Mortensen before the war. The work was continued by one of us (D. D. J.), who described those species which are new and commented on various other species; the remarks about the new species and the remaining specimens, the preparation of the figures and the final compilation were done by the other (A. M. C.).

The species taken are as follows (those marked with an asterisk being mentioned in the text):

Name	Station	Number of specimens
Asteroidea		
<i>Ctenodiscus crispatus</i> (Retzius)	11 (Newfoundland) and 6 (S.W. Greenland)	54
<i>Astropecten marginatus</i> Gray	36 (British Guiana)	3
<i>Astropecten antillensis</i> Lütken	35 (off R. Orinoco)	2
<i>Astropecten articulatus</i> (Say)	35 " "	1
* <i>Telhyaster vestitus</i> (Say)	35 " "	1
* <i>Luidia rosaurae</i> sp. n.	35 " "	3
* <i>Luidia barimae</i> sp. n.	35 " "	2
<i>Luidia senegalensis</i> (Lamarck)	36 (British Guiana)	1
<i>Luidia clathrata</i> (Say)	22 (British Honduras) and 37 (Brit. Guiana)	2
<i>Anthenoides piercei</i> Perrier	35 (off R. Orinoco) and 36 (Brit. Guiana)	4
<i>Nymphaster arenatus</i> (Perrier)	26 (Brit. Honduras) and 49 (off N.W. Africa)	3
<i>Goniaster cuspidatus</i> Gray	26 (Brit. Honduras) and 35 (off R. Orinoco)	2
* <i>Ceramaster granularis</i> forma <i>balteatus</i> (Sladen)	49 (off N.W. Africa)	9
<i>Echinaster sentus</i> (Say)	35 (off R. Orinoco)	1
<i>Henricia sanguinolenta</i> (O. F. Müller)	10 (South Labrador)	1
<i>Crossaster papposus</i> (Linnaeus)	10 " " and 11 (Newfoundland)	2
* <i>Brsingella coronata</i> (G. O. Sars)	49 (off N.W. Africa)	1
*Brsingidae—fragment	26 (British Honduras)	1 arm
<i>Zoroaster ackleyi</i> Perrier	26 " "	1
* <i>Stephanasterias albula</i> (Stimpson)	6 (S.W. Greenland)	2
<i>Leptasterias polaris</i> (Müller & Troschel)	9 (South Labrador)	1

Name	Station	Number of specimens
Ophiuroidea		
<i>Astrophyton muricatum</i> (Lamarck)	35 (off R. Orinoco)	1
<i>Astroporpa annulata</i> Lütken	35 " "	4
<i>Ophiacantha pentacrinus</i> Lütken	34 (Grenada)	1
<i>Ophiacantha metallacta</i> H. L. Clark	34 " "	116
<i>Ophiacantha bidentata</i> (Retzius)	11 (Newfoundland)	2
<i>Ophiomitra valida</i> Lyman	34 (Grenada)	3
* <i>Ophioplinthaca grenadensis</i> sp. n.	34 " "	1
<i>Ophioplinthaca incisa</i> (Lyman)	34 " and 26 (Brit. Honduras)	5
<i>Amphiura sundevalli</i> (M. & Tr.)	1 (Greenland)	1
* <i>Amphipholis gracillima</i> (Stimpson)	22 (British Honduras)	6
<i>Ophiactis savignyi</i> (M. & Tr.)	31 (Mosquito Bank, W.I.)	1
* <i>Ophiactis abyssicola</i> (Sars)	49 (off N.W. Africa)	10
<i>Ophiopholis aculeata</i> (Linnaeus)	1, 4, 6 (Greenland) and 10 (S. Labrador)	c. 34
* <i>Ophionereis dolabriformis</i> sp. n.	35 (off R. Orinoco)	1
<i>Ophiocoma echinata</i> (Lamarck)	16 (Grand Cayman Id.)	2
<i>Ophioderma brevicaudum</i> Lütken	37 (British Guiana)	2
* <i>Amphiophiura metabula</i> H. L. Clark	34 (Grenada) and 26 (Brit. Honduras)	6
<i>Ophiocten sericeum</i> (Forbes)	1 (Greenland)	6
<i>Stegophiura nodosa</i> (Lütken)	10 (S. Labrador)	1
* <i>Ophiomusium validum</i> Ljungman	26 (British Honduras)	65
<i>Ophiolepis elegans</i> Lütken	31 (Mosquito Bank, W.I.)	3
<i>Ophiura sarsi</i> Lütken	6 (Greenland) and 11 (Newfoundland)	45
* <i>Ophiermus adpersum</i> Lyman	34 (Grenada) and 26 (British Honduras)	6
Echinoidea		
<i>Tretocidaris bartletti</i> (A. Agassiz)	35 (off R. Orinoco)	5
<i>Salenocidaris rarispina</i> A. Ag.	26 (Brit. Honduras) and 49 (off N.W. Africa)	7
<i>Plesiodiademata antillarum</i> (A. Ag.)	26 (Brit. Honduras) and 49 (off N.W. Africa)	2
<i>Sperosoma grimaldii</i> Koehler	49 (off N.W. Africa)	9
<i>Calveriosoma hystrix</i> (W. Thomson)	49 " "	4
<i>Phormosoma placenta</i> W. Thomson	49 " "	1
<i>Triploneustes ventricosus</i> (Lamarck)	18 (Honduras)	2
<i>Strongylocentrotus dröbachiensis</i> (O. F. Müller)	1, 5 (Greenland), 9, 10 (South Labrador) and 12 (Nova Scotia)	c. 30
Holothuroidea		
<i>Holothuria mexicana</i> Ludwig	16 (Grand Cayman Id.)	1
<i>Mesothuria gayantua</i> Deichmann	26 (British Honduras)	1
<i>Phyllophorus pellucidus</i> (Fleming)	6 (Greenland)	1
<i>Chiridota laevis</i> (Fabricius)	5 and 6 (Greenland)	12
Crinoidea		
<i>Tropiometra carinata</i> (Lamarck)	37 (British Guiana)	10

Class ASTEROIDEA

Family ASTROPECTINIDAE

Tethyaster vestitus (Say)

Asterias vestita Say, 1825 : 143.

Sideriaster ? *vestitus*, Verrill, 1915 : 193.

St. 35. 9° 25' N., 59° 52' W. (off the mouth of the river Orinoco) ; otter trawl ; 86 m. One specimen.

$R = 70$ mm., $r = 16$ mm. $R/r = 4.3/1$.

This name was eventually arrived at after a great deal of correspondence with Mr. Austin Clark of Washington. He has recently received a huge Astropectinid from off North Carolina which answers very well to Say's description of *Asterias vestita* as far as that goes. This specimen has $R = 250$ mm., with a diameter of about 18 inches, probably as, compared with one of 14 inches for Say's lost type from Cape May, New Jersey, and it almost certainly represents the same species. A notable feature of this form is the development of large spatular ventro-lateral and infero-marginal spines, similar to, but less well-developed than, those of *Archaster magnificus* Bell from St. Helena in the south-east Atlantic. One of Bell's types with $R = 215$ mm., has these spines so large as to overlap, producing a very "shaggy" appearance, each spine being about 6 mm. long, whereas in the even larger specimen from North Carolina these spines are only about 4 mm. long. There seems to be no other significant difference between the two forms. Caso (1947 : 225) appears to think that *magnificus* is synonymous with *Sideriaster grandis* Verrill from the Gulf of Mexico. This opinion was shared by Mr. Clark and Dr. W. K. Fisher, but on the evidence of a number of specimens from the type locality Mr. Clark now concludes that *grandis* also is distinct from both *magnificus* and *vestitus*, being differentiated by the pointed (rather than truncated) form of the ventro-lateral and infero-marginal spines, developed only at a late stage (when R is more than 150 mm.) as in the latter. This is coupled with other features such as the relatively shorter dorsal paxillae in *grandis*.

The specimen taken by the "Rosaura" is too young for the ventro-lateral spines to have developed, so that it is not absolutely certain whether it represents *vestitus* or *grandis*. However, Mr. Clark has a large specimen with $R = 160$ mm. from Porto Rico which has small blunt ventro-lateral spines like *vestitus*. He therefore believes that *vestitus* occurs in the West Indies as well as up the East coast of the United States as far as New Jersey while *grandis* is limited to the Gulf of Mexico. This is similar to the distribution of *Astropecten articulatus* (Say), which extends from North Carolina (? New Jersey) south to Uruguay with a subspecies *valencienni* in the Gulf of Mexico, as pointed out by Mr. Clark. Whether the two forms of *Tethyaster* are specifically or subspecifically distinct is controversial.

As for the generic name used here, it was finally decided that *Tethyaster* Sladen with genotype *Asterias subinermis* Philippi embraces all the species formerly included in *Sideriaster* Verrill and *Moiraster* Sladen as well as *Anthosticta* Fisher. This

amalgamation will be discussed in more detail in a separate paper on *Tethyaster* by A. H. Clark and A. M. Clark. It is sufficient here to list the species included in the genus.

<i>subinermis</i> (Philippi) (genotype)	Mediterranean, Bay of Biscay to Mauritania.
<i>vestitus</i> (Say)	New Jersey to Venezuela.
<i>grandis</i> (Verrill)	St. Helena and Ascension.
<i>magnifica</i> (Bell)	Gulf of Mexico.
<i>aulophora</i> (Fisher)	Philippines.
<i>canaliculatus</i> (A. H. Clark)	Gulf of California.
<i>gigas</i> (Caso) (possibly only the large form of <i>canaliculatus</i>)	Gulf of California.
<i>pacci</i> (Mortensen)	South Africa.

Family LUIDIIDAE

Luidia rosaurae sp. n.

(Pl. 6 fig. 1; Text-figs. 1 and 2)

St. 35. 9° 25' N., 59° 52' W. (off the mouth of the river Orinoco); otter trawl; 86 m. Three specimens.

DIAGNOSIS. A species of *Luidia* with five rays belonging to the *Alternata* group of Döderlein; no enlarged dorsal spines present; the paxillae of the two outermost rows larger than those of the supero-marginal series; pedicellariae present on many of the dorsal paxillae particularly the lateral ones, as well as on the infero-marginal plates; four adambulacral spines on each plate, the two outermost arranged in a line parallel to the furrow; three- or four-valved pedicellariae on the ventro-lateral plates of many segments, especially proximally; one large marginal spine on each infero-marginal plate with small appressed ones on the ventral surface of the plate.

DESCRIPTION. The three specimens are all rather broken. Each has five rays. In the only one which has a complete and original (i.e., not regenerated) arm, R is about 53 mm. and r is 6.5 mm. $R/r = 8/1$.

The three outer rows of paxillae on the arms are larger than the remainder; the paxillae of the second and third rows are larger than those of the first. The paxillae of the first (i.e., supero-marginal) series, are rectangular, being slightly elongated. Those in the proximal part of the arm consist of 25-30 spinules, five to eight of which are in the centre, the remainder around the edge. In the centre of most there is also a small bivalved pedicellaria. The paxillae of the second and third rows are rectangular, being slightly longer in a transverse than a longitudinal direction; those shown in fig. 2 are foreshortened. At the base of the arm they consist of about 30 to 38 spinules, of which 14 to 16 are in the centre. The central spinules are heavier and blunter than the peripheral ones. A small number of these paxillae have two-valved pedicellariae among the central spinules.

The paxillae occupying the centre of the arm are smaller and roughly circular. At the base of the arm there are eight or nine rows of them, of which those of the

outer row on either side are slightly larger than the remainder. They consist of a central group of 14 to 16 spinules, of which those nearest the centre are heavy and blunt, and a peripheral circle of about the same number of spinules. In the paxillae in the middle of the arms the contrast between the central and peripheral spinules is more marked. There are up to eight central spinules, of which some or all are considerably heavier than the peripheral ones, of which there are about ten. These paxillae are very variable. They do not form regular rows. Those at the centre of the disc are of the same nature but smaller and more crowded.

The innermost adambulacral spine arises within the furrow. It is long and compressed and strongly recurved. A second and similar spine, not quite so recurved,

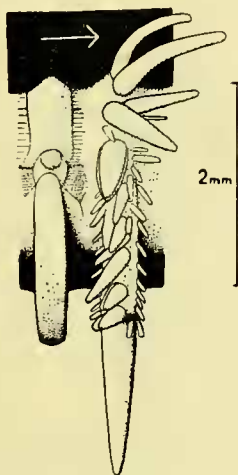


FIG. 1. *Luidia rosaurae* sp. n. Type. Ventral view of one side of two adjacent joints, that on the left having been denuded with sodium hypochlorite. (The spines are displaced sideways to avoid foreshortening as much as possible; the arrow points towards the mouth.)

occurs just outside it. External to this are two slightly shorter spines standing side by side; they are straight and compressed and taper from a wide base to a narrow tip. The outer part of the adambulacral plate is partly overlapped by the ventro-lateral plate which frequently carries a large and conspicuous three- or four-valved pedicellaria as well as several spinules. The pedicellariae are most numerous near the interbranchial angles.

The underside of each infero-marginal plate is raised into a strong ridge, the adjacent ridges being separated by deep grooves. The outer surfaces of the ridges are occupied by flattened spinelets of medium but varying lengths; fine spinules arise from the edges of the ridges. Near the outer edge there are often one or two pedicellariae, smaller than those of the ventro-lateral plates, of two, or more rarely three, valves. One strong, somewhat flattened, tapering spine nearly 2 mm. long

arises from near the upper edge of each plate forming a regular border to the arm. There is a paxilla-like group of spinules with one or two bi-valved pedicellariae above each spine, at least at the base of the arm. The outer parts of the arms are rather badly damaged.

When freshly preserved one of the specimens was straw coloured, with a brown patch in the centre of the disc continuous with broad brown bars running a short distance down the middle of each arm; there were also brown bands across the outer parts of the arms at intervals. The other two specimens were brown, but with deeper colour in areas corresponding to the brown parts of the first specimen. (After 15 years all colour has been lost.)

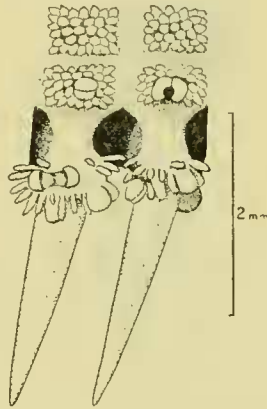


FIG. 2. Dorsal view of the top of two infero-marginal plates (seen in profile because of distortion in preservation causing an abrupt bend just above these plates) and the adjacent paxillae.

REMARKS. This species is obviously most closely related to *Luidia scotti* Bell (1917: 8), which is described fully in the third note on Asteroids in the British Museum by A. M. Clark (1953: 383). The types of *L. scotti* were taken off Rio de Janiero in 40 fathoms (73 metres). They differ from *L. rosaurae* chiefly in having much thicker, more stumpy spines and spinules on the ventral plates, a second enlarged marginal spine above the ambital one on the infero-marginals, and in having fewer ventro-lateral and infero-marginal pedicellariae and no dorsal ones.

This last character—the abundance of pedicellariae—is probably not of sufficient value to be used alone for specific distinction but the three points taken together are enough, on the evidence of the material available, to distinguish the two forms as separate species.

The second point is interesting since in the types of *Luidia doello-juradoi* Bernasconi (a synonym of *L. scotti* in the opinion of A.M.C.) from off Buenos Aires (Bernasconi, 1941 and 1943) the two large marginal spines on each infero-marginal plate are said to be nearly the same size, the upper being only slightly smaller. In the types

of *L. scotti* the upper spine averages only one-third of the length of the lower one, although occasionally it is two-thirds as long.

Luidia armata Ludwig (1905: 85) from the Gulf of Panama also has much in common with *Luidia rosaurae* but perhaps even more with *L. scotti*. It has ventro-lateral pedicellariae only in the interbrachial angles, but also has dorsal pedicellariae on the supero-marginal paxillae. Figures of this and of the other related species of *Luidia* described from Central and South America will probably show that they cannot all be maintained as valid species. This may be true of *Luidia armata* Ludwig, *L. ludwigi* Fisher (1906: 122 and 1911: 113), *L. scotti* Bell, *L. doello-juradoi* Bernasconi and *L. rosaurae*, which could represent local forms of a single species occurring on both sides of South and Central America. However, without Pacific specimens for comparison this suspicion cannot be verified.

Luidia barbadensis Perrier (1881: 29) also appears to be related to *L. rosaurae*. It is apparently usually six-rayed, whereas the three specimens of *L. rosaurae* are all five-rayed. The only pedicellariae described in *L. barbadensis* are said to be on the adambulacral plates (probably these are actually on the ventro-lateral plates as in related species) and in the interradial areas (Verrill, 1915: 205-7). In *Luidia rosaurae* they also occur on the outer paxillae of the arms dorsally and on the outer and lower surfaces of the infero-marginal plates. The infero-marginal plates of *L. barbadensis* bear two large spines on the margin of the ray. In *L. rosaurae* there is only one large marginal spine. There are also differences in the arrangement and proportions of the adambulacral spines of the two species. In the type of *L. barbadensis* with R = 125 mm. there are only two spines behind the furrow spine not three as in *L. rosaurae*, although Verrill (1915: 207) describes an "Albatross" specimen of *L. barbadensis* with four adambulacral spines arranged as in this new species.

A good series of specimens of *Luidia barbadensis* or detailed figures of the types are needed to define more clearly the relationships of the species.

Perrier's other six-rayed species *Luidia convexiuscula* (1881: 30), is based on a specimen with R only 28 mm. There appears to be no significant difference by which it can be distinguished from *L. barbadensis*, taking into account the very considerable size discrepancy between the types of the two species. The presence of three-valved pedicellariae only in the arm angles, only one enlarged marginal spine and the poor development of the adambulacral spines would be expected in such a young specimen.

Luidia barimae sp. n.

(Pl. 6, fig. 2; Text-figs. 3 and 4)

St. 35. 9° 25' N., 59° 52' W. (off the river Orinoco); otter trawl; 86 m. Two specimens.

DIAGNOSIS. A ten-rayed species of *Luidia* belonging to the *Quinaria* group of Döderlein, with all the dorsal paxillae irregularly arranged, some of them with one or more pedicellariae; no spino-paxillae; three adambulacral spines in a row at

right angles to the furrow ; one to four ventro-lateral pedicellariae ; no furrow pedicellariae except on the mouth plates ; infero-marginal plates extending on to the dorsal side, with four (sometimes three) large spines which alternate in position on adjacent plates.

DESCRIPTION. The two specimens are ten-rayed. Most of the arms are broken off near the disc and lost. The longest arm remaining attached to a specimen is 65 mm. long ; its tip is regenerated so that its length cannot be taken as a measurement of R. The radius of the disc is about 13 mm. The arms are constricted to a width of 9.5 mm. where they join the disc ; farther out they are 13 mm. wide.

None of the paxillae of the arms are arranged in regular rows. Those near the margin are somewhat bigger than, but otherwise similar to, those in the centre.

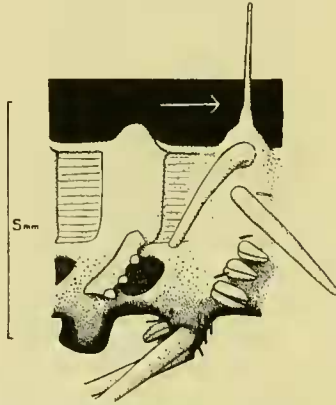


FIG. 3. *Luidia barimae* sp. n. Type. Ventral view of one side of two joints, that on the left having been denuded with sodium hypochlorite. (The arrow points towards the mouth.)

Each consists of a peripheral circle of eight to twelve widely spreading spinelets and a central spinelet, a little stouter but no longer than the peripheral ones. One of the peripheral spinelets is frequently replaced by a small bi-valved pedicellaria. There are no spino-paxillae.

The paxillae in the centre of the disc are small and much more crowded than those of the arms. In many the central spinelet is missing. Nearly every paxilla is supplied with a pedicellaria, while many have two. The pedicellaria sometimes arises from near the centre of the paxilla.

The madreporite is 2.5 mm. in diameter and may be trefoil-shaped ; it arises from very near the edge of the disc. A few paxillae appear to arise from it, but in reality project from between the lobes, not from the madreporite itself.

The bigger elements in the armature of the adambulacral, ventro-lateral and infero-marginal plates form one continuous transverse line from the furrow to the abactinal surface. The adambulacral armature consists of spines and pedicellariae.

There is a strongly curved furrow spine, about 3 mm. long; it is compressed to a blade-like form and its end is blunt. It is followed by another blunt compressed spine which is broader and may be longer, up to 4.5 mm. long; it may be bent at its base but is thereafter straight. There is a third spine which is nearly as long but much narrower, being only slightly compressed. A few spinelets usually arise from near the base of this spine on the adoral side. There may be a fourth and smaller spine borne on the inner end of the ventro-lateral plate, but it is usual for these plates to carry two or three large bi-valved pedicellariae, of which the outermost, about 1 mm. long, is larger than the inner ones. Small spinules may arise around the base of the pedicellariae, especially, in the proximal part of the arm, where there may even be four rather than three pedicellariae on each plate; in the distal part

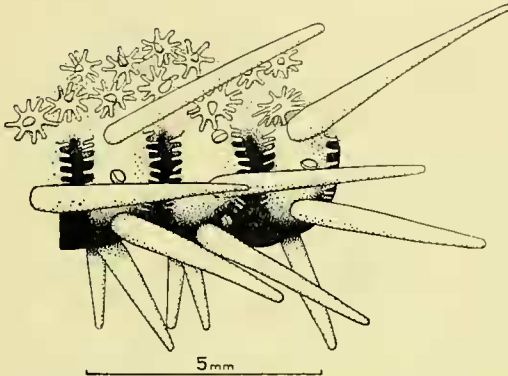


FIG. 4. Dorso-lateral view of three infero-marginal plates and the adjacent paxillae.

of the arm there is only one. There are no pedicellariae in the furrow as are found in *L. avicularia* and *L. integra*.

The infero-marginal plates encroach strongly on the abactinal surfaces of the arms. They are raised into strong ridges. In the proximal part of the arm there are four large spines on each plate. Three are on the lateral edge, one above the other, the lowermost shorter than the second and third which may be 6 mm. long. The fourth and longest spine, up to 8 mm. long, arises from or near the inner edge of the plate on the abactinal surface. The spines of adjacent plates arise at different levels as a rule, so that the uppermost spine of one plate is based on the extreme adradial edge, while that of the next plate is somewhat inset, the lower spines being correspondingly displaced on every second plate. On each row of infero-marginal plates there are thus eight series of spines, those of any one series all arising at the same level and usually only occurring on alternate plates. On those plates where the uppermost spine is not on the extreme inner edge of the plate there may be only three spines in the distal part of the arm. Numerous spinules occur in a thick row on the proximal and distal edges of the infero-marginal plates; they point into the furrows between the plates. One or two small bi-valved pedicellariae occur on

most of the plates, often on the innermost abactinal edge when there is no spine in that position.

Pedicellariae are numerous on the jaws and in the small interradial areas.

The colour of the spirit specimens is greyish-brown above, light below.

REMARKS. This species appears to be most nearly related to *Luidia heterozona* Fisher from West Africa (of which *L. mortenseni* Cadenat is a synonym), although that species is included by Fisher (1940 : 268) in the *Ciliaris* group since its supero-marginal plates are markedly larger than the adjacent lateral paxillae.

Döderlein's genealogical tree (1920 : 223) indicates that the *Ciliaris* group is very closely related to the subgenus *Integraster* of the *Quinaria* group (in which *L. barimae* seems to belong), and indeed *Luidia heterozona* is as much, if not more, in accord with the ten-rayed *Quinaria* group species such as *L. integra* Koehler, *L. avicularia* Fisher and *L. moroisoana* Goto as with the other species of the *Ciliaris* group, none of which has more than eight arms. In the subgenus *Integraster* the supero-marginal paxillae are larger and fewer in number than the adjacent rows of paxillae, even if not so conspicuously different as in *L. heterozona*. In *L. barimae* the lateral paxillae are much more irregularly arranged.

The only other notable difference between *L. heterozona* and this new West Indian species is in the number of infero-marginal spines, of which there are commonly four on each plate in *L. barimae* but only two or three in *L. heterozona*, although the conspicuous alternation in the position of these spines is similar. The number of pedicellariae between the outermost adambulacral spine and the lowermost infero-marginal one may be as many as three in some specimens of *L. heterozona* according to Madsen (1950 : 204), although the number is usually one. On the whole it seems better to regard *Luidia heterozona* as also belonging to the *Quinaria* group, it being the east Atlantic counterpart of *L. barimae*. Whether the differences between the two are less than specific, as with the east American *Luidia alternata* and its subspecies *numidica* from West Africa, remains to be seen from a greater range of West Atlantic material, showing the variation particularly of the armature of the infero-marginal and ventro-lateral plates.

The Indo-Pacific species *Luidia integra*, *L. avicularia* and *L. moroisoana* are easily distinguished from *L. barimae* by the possession of spino-paxillae, and in having a long-jawed pedicellaria within the furrow on the adambulacral plates.

Family GONIASTERIDAE

Ceramaster granularis forma *balteatus* (Sladen)

Pentagonaster balteatus Sladen, 1891 : 688, pl. 25, figs. 1-5.

Pentagonaster hystericis von Marenzeller, 1893 : 4, pl. 1, fig. 2, pl. 2, fig. 2 ; Ludwig, 1897 : 179, pl. 8, fig. 2.

Pentagonaster gosselini Perrier, 1894 : 399, pl. 26, fig. 4 ; 1896 : 45 ; Koehler, 1909 : 84, pl. 1, fig. 9.

Pentagonaster hevgroheni Koehler, 1896 : 63, pl. 2, figs. 8-10.

Ceramaster balteatus, Mortensen, 1927 : 82, text-fig. 45.

? *Pentagonaster haesitans* Perrier, 1894 : 397, pl. 23, fig. 7, pl. 25, fig. 2.

St. 49. $28^{\circ} 25' N.$, $13^{\circ} 34' W.$ (between Fuerteventura Island and Africa); agassiz trawl; c. 1300 m. Nine small specimens.

The typical north-European form of *Ceramaster granularis* (Retzius), from depths as shallow as 20 metres, is nearly pentagonal in outline, with the short triangular rays projecting abruptly. The R/r ratio equals c. 1.3 to 1.5/1, rarely more. The marginal plates of both series each have a bare patch, which is relatively larger in the young sea-star. There are usually three or four short, thick furrow spines and two, sometimes three, shorter spines in the second row backed by several rows of granules. The variations have been studied in detail by Grieg (1907: 22—32, text-figs. 1 and 2). It has been reported from off Morocco by Perrier and from the east coast of North America by Sladen and Verrill.

From south-west of Ireland to north-west Africa and the Mediterranean, at depths of more than 1,000 metres, is found a relatively longer-armed form with R/r averaging 1.7/1 and with the interbranchial arcs regularly curved, not angular. The marginal plates are more or less completely covered with granules and the furrow spines number from four to six on each adambulacral plate, with three spines in the second series backed by granules.

Several names have been given to such specimens, of which *Pentagonaster balteatus* Sladen has priority. Sladen's type was dredged in 750 fathoms (1,372 metres) in $51^{\circ} 01' N.$, $11^{\circ} 50' W.$ (south-west of Ireland). It has all the marginals completely covered with granules, $R/r = 1.7/1$, and there are six furrow spines on each plate, the adoral one being inset and shorter than the others.

Perrier originally described *Pentagonaster gosselini* as having only three or four furrow spines, but later (1896) mentions specimens with four to six adambulacral spines. The supero-marginal plates may be covered with granules or have bare patches according to Koehler (1909); Perrier says that their granulation is "fugace."

"*Pentagonaster*" *kerghoheni* Koehler from the Bay of Biscay in 1,710 metres has only the distal supero-marginals with a small bare patch free of granules. $R/r = 1.7/1$ and there are five furrow spines. Ludwig (1897) declares that *P. kerghoheni* is a synonym of *P. hystricis* von Marenzeller from the Mediterranean, which may also have small bare patches on the marginal plates. This seems very likely, although the Mediterranean form apparently has the granulation more spaced out than in Atlantic specimens. However, Ludwig is mistaken in thinking that *P. concinnus* Sladen and *P. greeni* Bell might also be synonyms of *P. hystricis*, for the former having only marginal granules on the dorsal plates is synonymous with *Plinthaster perrieri* (Sladen) as other authors have pointed out, while *P. greeni* does not have tabulate dorsal plates and like *Ceramaster placenta* (Müller & Troschel) might be referred to *Peltaster* Verrill.

Ludwig also says that older specimens of *P. hystricis* tend to have more numerous and larger bare patches on the marginals than young ones, which is the converse of what occurs in typical *granularis*. However the "Rosaura" specimens, the largest of which has R only 15 mm., all have bare patches on the supero-marginals and five of them on all the infero-marginals also. The other four, including the largest one, have the proximal infero-marginals completely covered with granules, and only the last two or three have a small bare patch. The R/r ratio varies between

1.45 and 1.7/1, averaging 1.6. The width of the marginals also seems to vary with the length of the arms, as they are broader when the shape is more pentagonal.

As for North American specimens of *Ceramaster granularis*, those collected by the "Challenger" south of Halifax, Nova Scotia, in 156 metres, differ little from the north European form except in having relatively longer arms, so that R/r averages 1.7/1. "*Pentagonaster*" *eximius* Verrill (1895) is a synonym of *Ceramaster granularis*, for Verrill's conception of the latter obviously approximates more to *balteatus* than to the typical form, as can be seen from his comparison. It seems quite probable that a longer-rayed form somewhat similar to *balteatus* occurs beside the typical one on the east coast of North America, just as typical *granularis* is found off North Africa according to Perrier, as well as the longer-armed form.

Family BRISINGIDAE

St. 26. 17° 53' N., 87° 44' W. (off British Honduras); agassiz trawl; c. 900m. One damaged arm fragment consisting of 46 joints, 95 mm. long.

At one end of the fragment the first and second adambulacral ossicles have, lying above and fused to them, two marginal plates, showing that this is the proximal part of an arm. The first marginal plate on one side is the same size as that on the other. The first two pairs of ambulacral plates are shorter than the remainder, which are each about 2.25 mm. long. The soft tissue is stripped off the first seven joints, but some remains on the dorsal side between the eighth and the sixteenth joints. Five costae, consisting of light ossicles with no spines, occur in that interval, that is, one to about every two joints. Beyond the sixteenth joint the arm consists of ambulacral and adambulacral ossicles, spines and shreds of tissue.

Each of the adambulacral ossicles carried a moderate-sized spine on its lower edge, a little nearer to the distal than the proximal end. Larger spines than these arise from the distal end of the outer edge of the adambulacral ossicles beyond the seventh; they appear to occur, with slight irregularities, on alternate ossicles. None is complete, the longest remaining being about 4.5 mm. long. The skin coverings of most are torn off but they are covered with numerous small crossed pedicellariae.

We cannot with confidence assign this fragment to any of the three species of the Brisingidae known from the Caribbean region: *Hymenodiscus agassizi* Perrier, *Odinia antillensis* A. H. Clark and *Freyella mexicana* A. H. Clark. What remains of the adambulacral spines are unlike those described for *O. antillensis* and *F. mexicana*. They are not unlike those of *H. agassizi*, and the structure of the arm is very like what Perrier describes for that species (1884: 189, pls. 1 and 2); the ambulacral ossicles have an exactly similar process for articulation with the adambulacral ossicles. Fisher (1918: 104, figs. 1 and 2) describes how the first marginals of *H. agassizi* which meet in an interbrachium are unequal in size. The first marginals of this single arm are of equal size; it may be that each met in its interbrachium a smaller first marginal. Fisher found that the abactinal integument of the rays of *H. agassizi* contained holothuroid plates. There are none in this specimen; there are on the other hand a number of light costae.

Brisingella coronata (G. O Sars)

Brisinga coronata G. O. Sars, 1871 : 5 ; 1875 : 1.

St. 49. 28° 25' N., 13° 34' W. (between Fuerteventura Island and Africa) ; agassiz trawl ; c. 1300 m. One disc.

The disc is of a young specimen, for it is only 12 mm. in diameter and the spines on its abactinal surface are fine and fairly far apart. There were eight arms.

Family ASTERIIDAE

Stephanasterias albula (Stimpson)

Asteracanthion albulus Stimpson, 1853 : 16, pl. 1, fig. 5.

Stephanasterias albula Heding, 1935 : 38.

St. 6. 60° 06' N., 45° 25' W. (off S.W. Greenland) ; three-feet dredge ; 110 m. Two specimens.

At first sight the larger specimen with $R = 11$ mm. appears to be five-rayed, but one of the larger arms has a very short arm coalesced with its proximal portion. The smaller specimen is six-rayed.

Class OPHIUROIDEA

Family OPHIACANTHIDAE

Ophioplinthaca grenadensis sp. n.

(Text-figs. 5-7.)

St. 34. 12° 05' N., 61° 49' W. (off St. George, Grenada) ; agassiz trawl ; 720-800 m. One specimen.

DIAGNOSIS. A species of *Ophioplinthaca* with oval, medium-sized, bare, radial shields ; long, tapering, rugous disc-spines not concealing the scales (at least in a dry specimen) ; the dorsal arm-plates triangular, the first two barely in contact (when the disc diameter is 5 mm.), the rest separate ; arm-spines flattened serrulate, five in number ; five acute oral papillae each side of each mouth angle ; adoral shields barely meeting interradially, but with a distal lobe separating the first lateral arm plate from the oral shield ; one large, oval, tentacle-scale throughout.

DESCRIPTION. The single specimen is dried and is rather twisted. Being dry the outlines of the plates show up more than in a spirit specimen. The disc diameter is 5 mm. ; there are five arms about 27 mm. long. The disc appears to be slightly indented in the interbranchial spaces. It is covered with large scales from most, if not all, of which arise strong glassy spines about 0.5 mm. long ; they are thick at the base but rapidly taper, sending off smaller spines on all sides and ending in two or three thorns. The radial shields are moderately large, naked, convex and about 1 mm. long. They are separated from one another by a wedge of scales bearing spines ; the wedge narrows from three scales within to one without.

The first two dorsal arm-plates are just in contact with one another, but beyond the second one the plates become more and more widely separated from one another. They are of a simple triangular shape, about as wide as long, with a sharp angle within, quite straight lateral edges and a gently curved distal edge. The side-plates are large and raised into strong spine-ridges. Those of the distal segments are very long.

There are five glassy arm-spines, increasing in length from the lowermost, which is as long as one segment, to the uppermost, which may be as long as two segments. They are of a characteristic shape, being flattened with each of the two blade-like edges produced into a row of teeth. The dorsal ones taper to a blunt end but the ventral spines have the end truncated, each corner being produced into a tooth.

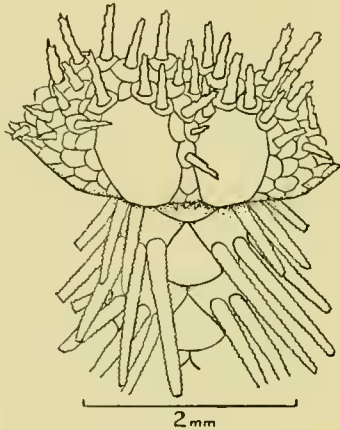


FIG. 5. *Ophioplinthaca grenadensis* sp. n. Type. Dorsal view of the base of an arm and part of the disk.

The proximal ventral arm-plates are just separated from one another; those at the end of the arm are very widely separated. They are five-sided. The two straight or slightly concave proximal sides form an angle; the lateral sides are deeply concave; the distal edge is widely rounded. The proximal plates are slightly broader than long; those further out on the arm are longer than broad.

The tentacle-scale is single and very large. It is leaf-like with a rounded free end on the proximal segments, a more pointed end on the distal segments.

The interbrachial spaces on the ventral side are covered with large, overlapping scales without spines. The oral shields are shaped like a broad spear-head, about as wide as long. The proximal sides are slightly convex, the distal concave; the distal angle is much more broadly rounded than the proximal. The adoral shields are tri-lobed. The long inner lobe narrows to a point which may be just in contact with its fellow. The outer lobes separate the oral shield from the first lateral arm-plate.

There are five or six similar triangular oral papillae on each side of the jaw and one much larger, below the teeth, at the apex.

The colour of the preserved specimen is white.

REMARKS. Having the radial shields not bar-like but oval and naked, this species cannot be included in the genus *Ophiacantha* in the restricted sense. It seems to fall within the group of genera *Ophiomitrella*, *Ophiophthalmus* and *Ophioplinthaca* by virtue of the armature of the mouth-plates and the more or less distinct disc scales.

It is distinguished from *Ophiomitrella* Verrill (1899a : 332) by the presence of distal lobes to the adoral shields interposed between the first lateral arm-plates and the oral shields. Koehler (1922 : 124) has separated off the two species which show this character from the rest of the genus *Ophiomitrella* by creating a new genus *Ophiomelina*. However, these two species have such insignificant radial shields that

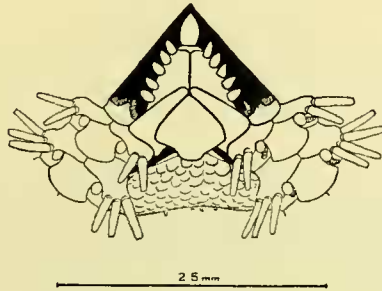


FIG. 6. Ventral view of an interbranchial angle and the bases of the two adjacent arms. (Some of the tentacles are drawn in.)

they are obviously not congeneric with this new species. *Ophiophthalmus* Matsumoto has been limited and redefined by Koehler (1922 : 121), who relegated some of the species to *Ophiomitrella* and others to *Ophiomelina*. None of the species left in *Ophiophthalmus* has a distal lobe to the adoral shields, which instead meet widely interradially although *Ophiophthalmus hylacantha* (H. L. Clark 1911 : 227) does have thorny tapering disc-spines, arm-spines, radial shields, ventral arm-plates and tentacle-scales very like this new species.

Ophioplinthaca Verrill (1899a : 351), which grades into *Ophiomitrella*, includes forms with oral papillae in a simple series, a single apical papilla, relatively large bare radial shields and the disc notched interradially usually with specialized marginal scales. Except for the last character, which is indistinct in the immature specimen of *O. grenadensis*, it conforms quite well to the other species of *Ophioplinthaca*. However most of these, like *Ophiomitrella*, have the adoral shields lacking a distal lobe between the first lateral arm-plate and the oral shield. *Ophioplinthaca partita* (Lütken & Mortensen 1899 : 179), from the west coast of Mexico, included in this genus by H. L. Clark in 1915, differs from the rest in this respect. It seems to be

congeneric with this new species which is accordingly placed in the genus *Ophioplinthaca*.

Within the genus, *Ophioplinthaca rudis* (Koehler) (1922: 142, pl. 96, fig. 1) has disc-spines which are just like those of *O. grenadensis*, although their occurrence is very variable and they may be completely absent, as illustrated by Koehler. From *Ophioplinthaca incisa* (Lyman 1883), also taken at station 34, this new species differs most obviously in having relatively smaller adoral and larger oral shields, more numerous and spaced oral papillae, single tentacle-scales on the first pores and much finer thorns on the arm-spines.



FIG. 7. *a*, Two spinelets from the disk, and *b*, a short blunt lower arm-spine and a long upper one.

The genus *Ophioplinthaca* is also characterized by the presence of broad dorsal arm-plates which are in contact in the proximal part of the arm of the adult. However, the relatively small plates of *O. grenadensis* may also be shown by young specimens of the other species of comparable size. This is illustrated in Koehler's photographs of *Ophioplinthaca globata* (1922), from the Philippine area.

The saw-like arm-spines are similar to those of *Ophiacantha hirsuta* Lyman (1875) as well as to the spines of Verrill's genus *Ophiopristsis* although that genus is also characterized by the complex oral armature with several apical papillae.

In the present state of the family Ophiocanthidae the generic positions of many species are open to some doubt and a thorough revision is needed to clear up the limits of the genera.

Family OPHIACANTHIDAE

Ophiactis abyssicola (Sars)

Amphiura abyssicola Sars, 1861: 18, pl. 2, figs. 7-12.

Ophiactis abyssicola, Ljungman, 1867: 324.

St. 49. 28° 25' N., 13° 34' W. (between Fuerteventura Island and Africa); agassiz trawl; c. 1,300 m. Ten specimens.

A note by Mr. Colman on the original label describes the arms as scarlet and the body slaty-blue in life. Most of the specimens were on sponges, but it is not known whether this is a natural association or one which came about in the trawl. The disc of the largest is 7 mm. in diameter.

Family AMPHIURIDAE

Amphipholis gracillima (Stimpson)

(Text-fig. 8).

Ophiolepis gracillima Stimpson, 1852: 224.*Amphipholis gracillima*, Ljungman, 1867: 314.

St. 22. $17^{\circ} 28' N.$, $88^{\circ} 11' W.$ (Belize Harbour, British Honduras); two-feet dredge; 6 m. Six specimens.

Most of Stimpson's original specimens had lost their discs, as three of the present specimens have done. None has complete arms but many long fragments remain, and where they are fractured they show no sign of tapering to an end.

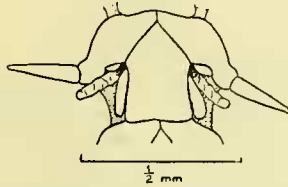


FIG. 8. *Amphipholis gracillima* (Stimpson). Ventral view of a middle arm segment.

The species does not appear to have been described as possessing tentacle-scales. The present specimens have two, a long narrow inner scale reaching slightly further than the segment to which it belongs, and a small outer scale.

One specimen sent to the late Dr. H. L. Clark of the Museum of Comparative Zoology, was compared by him with a specimen of the same size from Tobago and with one of the types of *Amphipholis gracillima*. He thought there was no doubt that the "Rosaura" specimens belong to this species, but their tentacle-scales, particularly the inner, are bigger than in the type and the Tobago specimen. They are accordingly figured here.

The specimens retain in spirit bars of a rich reddish colour at the distal end of each arm-segment on the underside.

Family OPHIOCHITONIDAE

*Ophionereis dolabrisformis*¹ sp. n.²

(Text-figs. 9-11).

St. 35. $9^{\circ} 25' N.$, $59^{\circ} 52' W.$ (off the mouth of the river Orinoco); otter trawl; 86 m. One specimen.

DIAGNOSIS. A species of *Ophionereis* with very fine disc-scales, becoming a little larger around the radial shields; supplementary dorsal arm-plates very small

¹ *dolabrisformis* = axe-shaped, referring to the ventral arm-plates.

² Owing to delay in publication of this paper a brief description of this species has already appeared in print. (A. M. Clark, 1953, A Revision of the genus *Ophionereis*. *Proc. Zool. Soc. Lond.* 123: 65-94.)

and limited to the distal half of the joint, even on the proximal segments; three long, tapering arm-spines which vary irregularly in relative length, the uppermost usually the longest, sometimes exceeding one-and-a-half times the length of the corresponding joint, the middle one sometimes the shortest but often all three about the same length; adoral shields barely meeting interradially and also narrow outwardly, being overlapped by the oral shield which, at its widest part just reaches the first lateral arm-plate on each side; disc coloured with very compact dark reticulations.

DESCRIPTION. The specimen has been dried and the disc has perforated centrally so that the teeth are visible from the dorsal side through the gap. It has contracted

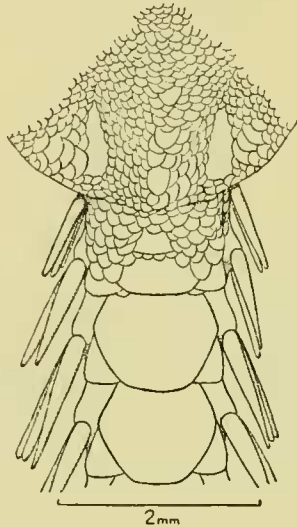


FIG. 9. *Ophionereis dolabriformis* sp. n. Type. Dorsal view of the base of an arm and part of the disk.

considerably in the interradiial areas so that the diameter is hard to measure; it is about 8 mm. All the arms are broken, the longest remaining being about 40 mm. in length and still quite stout at the end of that distance, the total length being probably in the region of 70 mm.

The disc scaling is fine but a little coarser around the radial shields, a few of the mid-radial scales being enlarged also. On the ventral side it is fairly uniform up to the genital slits, which lack papillae. The scaling extends out on to the dorsal side of the arm-bases for several segments.

The dorsal arm-plates are hexagonal in shape, the widest part being about the middle. The two latero-proximal sides are in contact with the lateral arm-plates, while the latero-distal sides (which usually curve round into the distal side) are

bordered by the short supplementary arm-plates, which are triangular with a curved distal edge.

The lateral arm-plates bear three long, needle-like, tapering spines of varying relative length; they may all be equal, or the uppermost may be longest and the middle one shortest, or the uppermost may be the shortest and the other two about equal. Their maximum length exceeds one-and-a-half times the length of the corresponding joint.

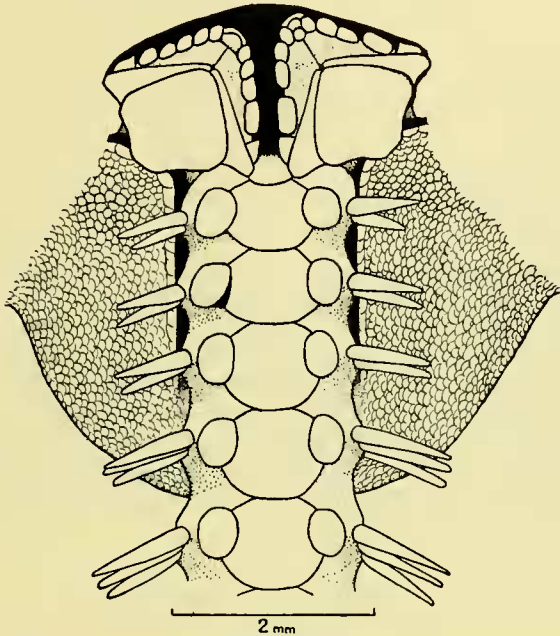


FIG. 10. Ventral view of the base of an arm and the adjacent interradial areas.

The ventral arm-plates are shaped like a battle-axe head, with the distal edge very convex and a little wider at the distal end of the tentacle-scales than proximal to them. (This form might also be interpreted as "bell-shaped"). After the first few the plates are a little longer than wide.

There is one large, oval tentacle-scale completely covering each pore.

The oral shields are broadly spear-head-shaped, the widest part being towards the distal end and the two nearly straight proximal sides meet at an angle, while the shorter distal sides are each slightly concave across the head of the genital slit but form a blunt distal angle. The adoral shields are not very large and are completely overlapped by the oral shields at their widest point. Internally they just meet inside all the oral shields except the madreporite, which is a little larger and is

swollen. There are four or five oral papillae on each side, the outermost being the largest when they are four; on some angles there is a small apical papilla, but on others the lowest tooth is clearly visible. Beyond the outermost papilla is an oral tentacle-scale.

The disc is marked with very close dark reticulations, much more compact than those of *O. reticulata*. On the arms at intervals of three or four segments there are brownish-purple bands, each extending for one-and-a-half segments. Besides

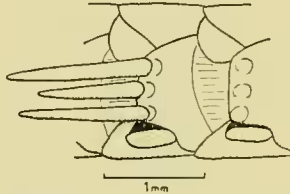


FIG. 11. Lateral view of part of an arm.

these there are fainter markings elsewhere on the dorsal sides of the arms, including an ill-defined longitudinal line down the centre of the arm.

REMARKS. The other three West Indian species of *Ophionereis* are *O. reticulata* (Say), which is very common, *O. squamulosa* Koehler, known from St Thomas, Parahiba in Brazil and common at Tobago and the Tortugas according to Dr. H. L. Clark, and finally *O. olivacea* H. L. Clark, known only from two specimens, from Porto Rico and Florida. Dr. Clark has given a key to the identification of these (1933: 39). *Ophionereis dolabriformis* differs from the first two named above by its small supplementary arm-plates and from all three by the needle-like arm-spines and the coloration of the disc.

Family OPHIOLEPIDAE

Amphiophiura metabula H. L. Clark

Amphiophiura metabula H. L. Clark, 1915: 311, pl. 17, figs. 1-3.

St. 26. 17° 53' N. 87° 44' W. (off British Honduras); agassiz trawl; c. 900 m. Four specimens.

St. 34. 12° 05' N., 61° 49' W. (off St. George, Grenada); agassiz trawl, 720-800 m. Two specimens.

The largest have discs 8 mm. in diameter. They agree in every way with Clark's photographs except that the arm-spines are only four, or on the proximal segments five, in number, and that they are widely separated and of minute size—less conspicuous than in Clark's picture. Where there are four, the lowermost is close against the tentacle-scales, the uppermost close to the dorsal plate; the other two are so placed that the distance between all four spines is equal, or so that the distance

between the middle two is slightly greater than that between the first and second and between the third and fourth. Clark's fig. 3 shows at least six arm-spines, close against one another and occupying the whole distal edge of the lateral plate.

There are two specimens in the British Museum collection which were labelled *Ophioglypha variabilis* from "Blake" station 227, 573 fathoms (1,048 metres) off St. Vincent. They of the same size as the "Rosaura" specimens and agree with them in every way, including the arm-spines.

Ophiomusium validum Ljungman

Ophiomusium validum Ljungman, 1871: 618.

St. 26. 17° 53' N., 87° 44' W. (off British Honduras); agassiz trawl; c. 900 m. Sixty-five specimens.

The diameter of the disc is up to 10 mm., which is greater than Lyman gives. There is a far larger specimen, diameter 17 mm. among three in the British Museum from "Blake" station 238, 127 fathoms (232 metres) in the Grenadines. Lyman (1878, pl. 1, fig. 9) shows four equally spaced arm-spines. Most of the present specimens and some of the "Challenger" ones in the British Museum collection have only three spines, the third (the highest) a greater distance from the second than the second is from the first. Some have four spines at the base of the arms, as the "Blake" specimens do; the two lowermost spines are closer together than the second and third and the third and fourth.

Minute ventral arm-plates are present for a short distance beyond the third segment; they persist a long way out in the large "Blake" specimens.

The radial shields are usually contiguous without, but they are sometimes completely separated as in the large "Blake" specimens.

Family OPHIOLEUCIDAE

Ophiernus adpersus Lyman

(Text-fig. 12)

Ophiernus adpersus Lyman, 1883: 236, pl. 3, figs. 19-21.

St. 26. 17° 53' N., 87° 44' W. (off British Honduras); agassiz trawl; c. 900 m. One specimen.

St. 34. 12° 05' N., 61° 49' W. (off St. George, Grenada); agassiz trawl, 720-800 m. Five specimens.

The six rather broken specimens from this collection and two co-types in the British Museum from "Blake" station 185, Dominica, 333 fathoms (610 metres), all show a character which has not been described in this species or in any other of the genus. A single closely placed row of fine glassy bristles arises from the distal

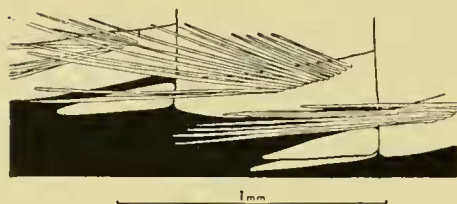


FIG. 12. *Ophiernus adpersus* Lyman. Dorsal view of part of an arm to show the bristles on the lateral arm-plates.

edges of the side plates on the dorsal side of the arm. In the proximal part of the arm they are slightly longer than an arm joint; farther out on the arm they are longer.

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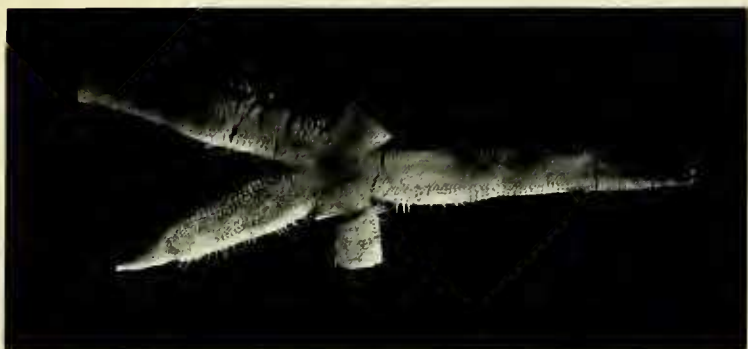


FIG. 1

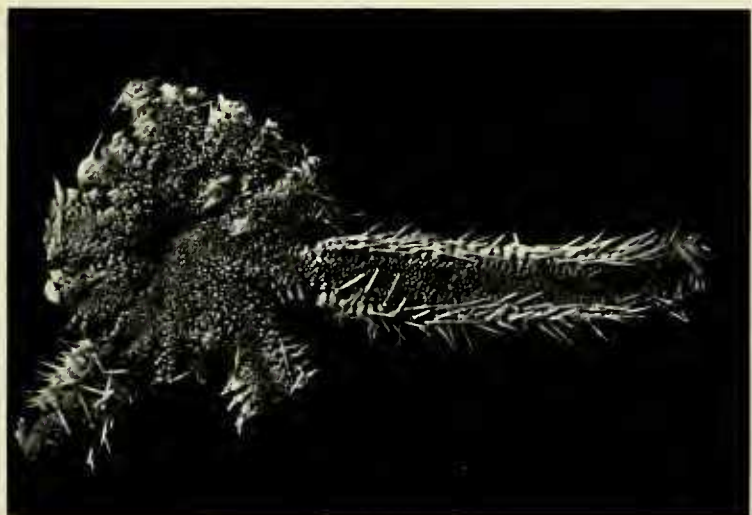


FIG. 2

Plate 6, fig. 1. *Luidia rosaurae* sp. n. Type. Dorsal view. Fig. 2. *Luidia barimae* sp. n. Type. Dorsal view. Both natural size.